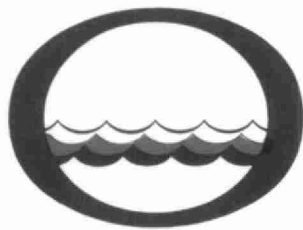


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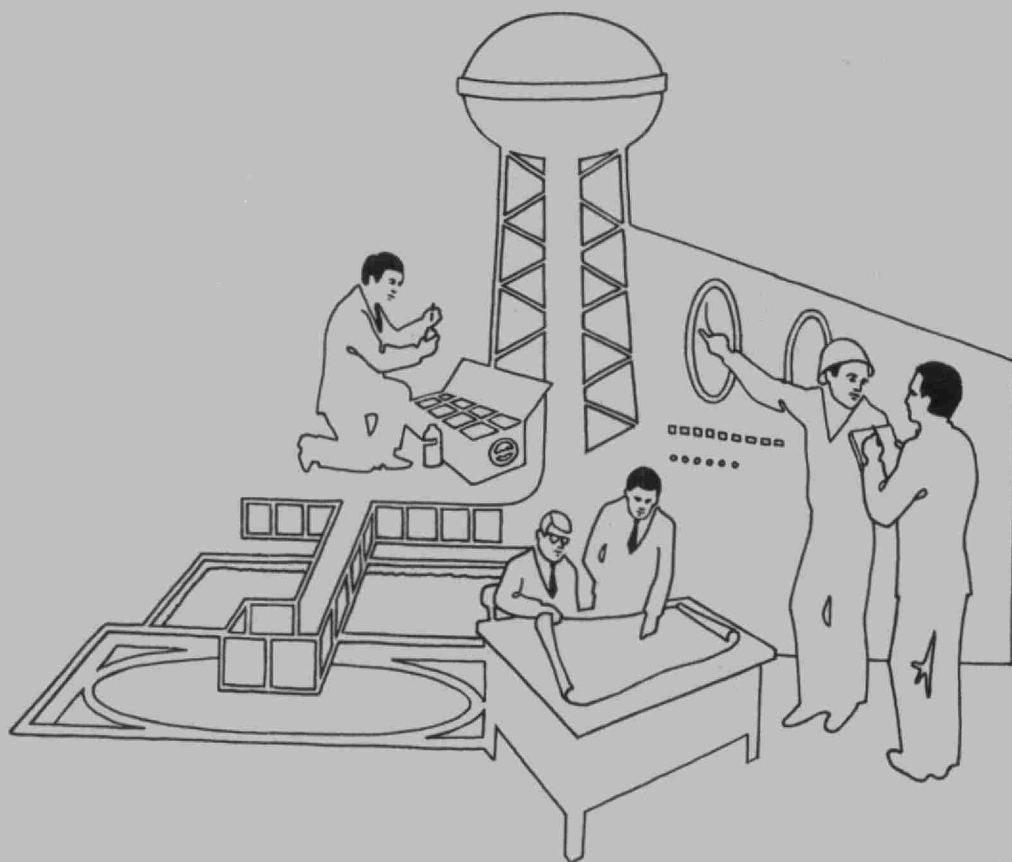
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1970 RECREATIONAL LAKES PROGRAM

RILEY LAKE

in the

DISTRICT MUNICIPALITY OF MUSKOKA

TD
370
.R43
1971
MOE

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1970 RECREATIONAL LAKES PROGRAM

RILEY LAKE

in the

DISTRICT MUNICIPALITY OF MUSKOKA

Division of Sanitary Engineering
District Engineers Branch

June 1971

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SUMMARY AND CONCLUSIONS

A water quality study of Riley Lake in the District Municipality of Muskoka was performed during and subsequent to the height of the 1970 summer tourist season.

The bacteriological results indicated that bacterial levels were below the OWRC criteria for total body contact recreational use during both survey periods. During the mid-tourist season survey, the geometric mean densities for the entire lake were 263.5 total coliform organisms per 100 ml, 8.9 fecal coliform organisms per 100 ml and 2.5 fecal fecal organisms per 100 ml. The total and fecal coliform levels were significantly lower during the fall survey. The fecal streptococcus level was slightly higher. The fecal coliform count exceeded 100 organisms per 100 ml at twelve stations throughout the lake mainly on Monday, July 6, and once on July 7; the data suggest that fecal contaminants from Riley Creek and the lake environs entered the lake.

The dissolved oxygen content in the surface waters was satisfactory during both surveys. Most of the lake except the southern arm was thermally stratified during the mid-tourist season survey. Serious oxygen depletion existed in the waters below the thermocline. Thermal

stratification along with very low oxygen content in the bottom waters continued into the post-tourist season survey only in the middle and east arm. It is noted that the oxygen content in waters below the thermocline did not meet the OWRC criteria for the preservation of warm water biota.

The thermal stratification in the west arm of the lake had disappeared due to natural processes but some oxygen depletion continued in the bottom waters. The oxygen depletion (noted in both surveys) is attributed to the oxygen demand exerted by the decomposing sediments.

The dissolved oxygen curves recorded in Riley Lake are of the clinograde type and are characteristic of eutrophic lakes; this is in harmony with the findings of an OWRC study conducted in 1969 by Messrs. Michalski and Robinson.

The samples analyzed for chemical parameters revealed the surface waters to be of satisfactory quality. The mineral content was found to be quite low; the hardness during the fall survey ranged from 12 to 18 ppm.

INTRODUCTION

As a result of recommendations in the March, 1970 report on Environmental Management of Recreational Waters in Cottage Areas in Ontario, field surveys were conducted on recreational lakes. In this interdepartmental program, staff of the OWRC would conduct water quality studies, while staff of the Ontario Department of Health's Public Health Engineering Service would conduct investigations of on-shore private sewage disposal systems.

Since the Department of Health had already conducted its investigations on the shore line of Riley Lake prior to 1970, staff of the OWRC conducted two surveys during the periods of July 5 to 9, and September 24 to 27, 1970.

DESCRIPTION OF LAKE

Riley Lake is located in the Black River watershed in the Township of Ryde, District Municipality of Muskoka, some 10 miles south-east of Gravenhurst. The lake receives drainage from the north and east via small creeks such as Riley Creek; it also appears to be spring-fed (see OWRC report on Status of Enrichment of Riley Lake - Michalski and Robinson, December 1970). The lake flows southward via Riley Creek to the Black River, nearly three miles away.

The lake has been described in the aforementioned report as ".... stellate-shaped.... The lake has an estimated surface area of 350 acres, a maximum depth of 95 feet (13.5 m) and a mean depth of 19.5 feet (5.8 m)".

Development consists almost entirely of cottages. Some areas such as Ball's Bay and the east arm of the lake have lesser amounts of cottage development.

SAMPLING CONDITIONS

Of particular significance is the fact that each survey represented different conditions with respect to recreational use of the lake waters. The July or mid-tourist season (MID) survey was conducted during the height of the tourist season. However, recreational use had declined considerably by the time of the September or post-tourist season (POST) survey. Each survey also included part or an entire weekend.

A record of the air temperature, wind direction and approximate wind velocity during each sampling period was kept by the sampling crew. A summary of this data together with the rainfall recorded at the Muskoka Airport weather station (located just north of Gravenhurst) is found in Table I.

TABLE I
OBSERVED WEATHER CONDITIONS

DATE	AIR TEMPERATURE °C		WIND		COMMENTS	* RECORDED RAINFALL (in.)
	Avg.	Range	Dir. (°N)	Vel. (mph)		
July 4	-	-	-	-		.97
July 5	24	23 - 27	270	7		trace
July 6	26	24 - 28	-	nil		0
July 7	20	19 - 20	-	nil		0
July 8	24	-	160	3	overcast	.06
July 9	20	19 - 21	-	nil		.01
Sept. 23	-	-	-	-		0
Sept. 24	24	24 - 25	140	12	slight overcast	.62
Sept. 25	18	17 - 22	-	nil		0
Sept. 26	21	21 - 22	180	15	overcast	.58
Sept. 27	9	-	180	4	overcast	.10

* Muskoka Airport weather station north of Gravenhurst

FIELD WORK

Water samples were collected for bacteriological and chemical analyses in a laboratory as well as field determinations of temperature, dissolved oxygen and pH by means of electronic instruments. The sampling point locations are shown on the map enclosed in this report. In addition to the foregoing, the temperature and dissolved oxygen at various depths were recorded at several locations in the lake.

During the two surveys, 24 stations were

sampled daily at the surface for bacteriological analyses; during the POST survey, depth samples were collected also at two of these stations.

A total of 19 stations were sampled during the MID survey at least once for chemical analyses; one of these stations was sampled twice. During the POST survey, four stations which included 6, 19, 22 and 15 were sampled daily for chemical analyses.

The surface bacteriological samples were collected in sterile 250 ml autoclavable polycarbonate bottles from approximately one meter below the water surface. Depth bacteriological samples were collected using sterile 237 ml air syringes employing a modified "piggy-back" sampler as a depth of one to two meters above the lake bottom. Immediately after collection, the samples were stored in ice for preservation until delivered to a nearby OWRC mobile bacteriological laboratory for analysis.

The chemical samples were collected in two 32-ounce bottles from a depth of about one meter below the surface. Then the samples were either shipped or delivered to the OWRC Laboratory in Toronto for analysis.

LABORATORY ANALYSES OF SAMPLES

All bacteriological samples were analyzed

at the mobile laboratory for total coliform (TC), fecal coliform (FC) and fecal streptococcus (FS), usually 6 to 8 hours after sampling, at the mobile laboratory. Analyses were performed using the membrane filter technique as specified in "Standard Methods for the Examination of Water and Wastewater", twelfth edition 1965, APHA, AWWA, WPCF. The only modification was the use of MacConkey MF broth in the FC analysis.

The OWRC Laboratory in Toronto analyzed the chemical samples for up to 15 chemical constituents which included nitrogen and phosphorus determinations.

METHOD OF BACTERIOLOGICAL EVALUATION

A statistical evaluation of the results was made on the logarithm of the bacterial counts with the central tendency being measured by the geometric mean. The significance of differences between stations in each survey was evaluated by the use of an analysis of variance or F-test. The differences between the surveys were evaluated by the use of the Student's t-test. All geometric means were compared with the water quality criteria for total body contact recreation as outlined in the OWRC's "Guidelines and Criteria for Water Quality Management in Ontario" (June 1970). These criteria state

that recreational waters can be considered impaired when the geometric mean densities exceed any of the following:

1,000 total coliform organisms per 100 ml

100 fecal coliform organisms per 100 ml

20 fecal streptococci organisms per 100 ml

BACTERIOLOGICAL RESULTS

A summary of the statistical evaluation of the bacterial counts is found in Table III. An explanation of the terms used therein is found in Appendix B.

Table III shows that there was no significant difference at the 5% significance level between stations for any parameter in either survey but that there was a significant difference at the 5% significance level between surveys for any parameter. All geometric means were below the recreational water quality criteria.

During the MID (July) survey, the bacterial parametric levels were 263.5 TC/100 ml, 8.9 FC/100 ml and 2.5 FS/100 ml.

The TC and FC counts were significantly lower at 165.4/100 ml and 3.7/100 ml respectively during the POST (September) survey. The FS level during the September survey was slightly higher at 3.4/100 ml.

It was noted that the FC counts exceeded 100 FC/100 ml at 11 stations on July 6 (Stations 1, 3, 4, 8, 9, 11, 15, 19, 20, 22 and 24) and at Stations 13 on July 7. Smaller increases also occurred at four other stations on July 6. Although the flow in Riley Creek appears to contribute towards some of these counts, the timing of the FC increase and location thereof, together with little precipitation, suggests a delayed fecal waste input from the lake environs, such input probably being due to increased human activity on the weekend.

DISSOLVED OXYGEN, TEMPERATURE AND pH CONSIDERATIONS

The dissolved oxygen, temperature and pH measurements taken at the various stations are summarized in Table II.

During the MID survey, the surface temperature varied from 19.6 to 20.6°C. Dissolved oxygen contents were high and ranged from 102% to 113% saturation.

By the time of the fall survey, the temperature had fallen to a range of 17.2 to 17.3°C. The dissolved oxygen had also declined to 84% to 98% saturation which is still satisfactory.

The pH measurements during the fall survey indicated a pH range of 5.4 to 6.4. Values tended to be lower in the west arm of the lake. The individual readings revealed a peak occurring on September 26 at most stations; the reason for this phenomenon was not apparent.

The profile studies during the MID survey were conducted on July 8th at Stations 16, 13, 19, 22 and north of 7. At Stations 16 and 13, no thermal stratification was evident and oxygen contents were 88% or higher down to 10 feet below the surface. Stratification was apparent at Stations 19 and 22, although insufficient data is available to locate the zone of transition (thermocline).

At Station 19, a temperature drop of 4° occurred within a depth of 7 feet and the oxygen content decreased from 120% at the 3-foot level to 79% at the 10-foot level; the pH also dropped from 6.9 to 5.9. At Station 22, the dissolved oxygen and temperature decreased from 112% to 20% saturation and from 22.5° to 11°C , respectively, within a distance of 32 feet.

The waters of the west arm of the lake north of Station 7 were found to be thermally stratified on July 8 (See Figure 1). A pronounced thermocline having a temperature drop of 8° within 6 feet was present between 5 and 11 feet below the surface. It is interesting that the recorded depth was only about 13 feet. The dissolved oxygen content declined from over 100% above the thermocline to 2% saturation at 13 feet below the surface. By the time of the fall survey, no thermal stratification was found in this section; however a decrease in the dissolved oxygen content from 90% at the surface to 42% saturation at the bottom was observed.

During the POST survey, thermal stratification was evident at Station 22 on September 25

(See Figure 1). The temperature drop in the thermocline (located between 24 and 30 feet below the surface) was 6.5°. The dissolved oxygen content exceeded 80% above the thermocline but was less than 5% below it. The low temperatures and dissolved oxygen contents found on September 25 are consistent the average results of 10°C and 4% saturation measured at this station during the entire POST survey. The low dissolved oxygen and temperature obtained during the entire survey at Station 18 (located about 3/4 mile easterly) at a depth of some 40 feet below the surface are quite similar to those at Station 22 at the same depth.

The aforementioned oxygen depletion in the waters below the thermocline is due to the oxygen demand of the decomposing sediments. The clinograde oxygen curve is characteristic of an eutrophic lake. It is noted that Michalski and Robinson (see OWRC report) found this lake to be eutrophic.

CHEMISTRY

The laboratory results pertaining to the chemical samples are found in Table IV (MID survey) and Table V (POST survey),


The results for both surveys reveal the surface water to be of satisfactory quality. The calcium

and magnesium content (hence hardness) were quite low. Low chlorides of approximately 2 ppm were obtained and the conductivity varied between 31 and 35 micromhos per cm^3 . The alkalinity was also low ranging between 5 and 10 ppm.

The MID survey results respecting the remaining parameters also indicated satisfactory quality. Although too small to ascertain significance, variations were noted. The free ammonia nitrogen rose from .02 ppm on the first day to .08 ppm on the second and then declined gradually. The total kjeldahl nitrogen remained at approximately 0.60 ppm for the first three days and then decreased to .40 ppm, although some high values were obtained on July 9. The nitrite content increased from .008 ppm on July 5 to approximately .012 on July 6 and 7 and then decreased to about .005 ppm on the remaining two days. Total phosphorus decreased from .027 ppm on the first day to about .016 ppm on the remaining days. The iron gradually decreased while the carbon increased during the survey.

The POST survey indicated little change in the water as it passed through Riley Lake. The nitrogen, phosphorus, iron and carbon contents were generally of

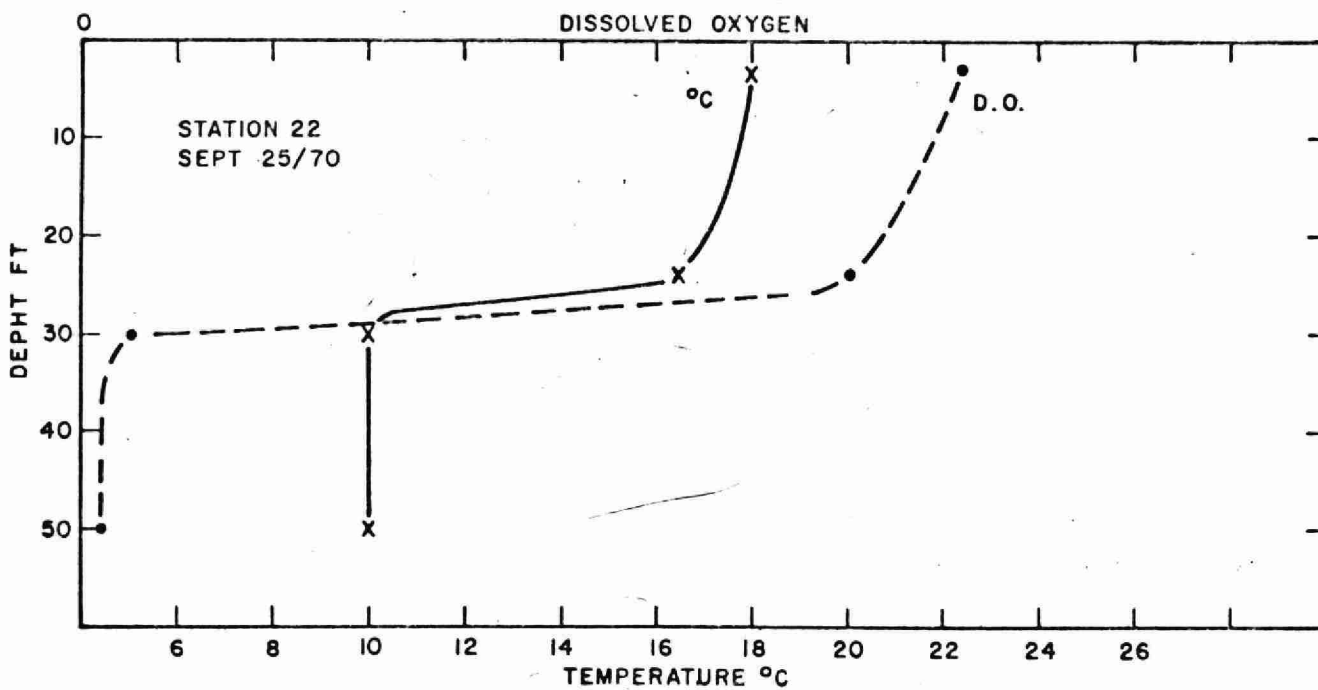
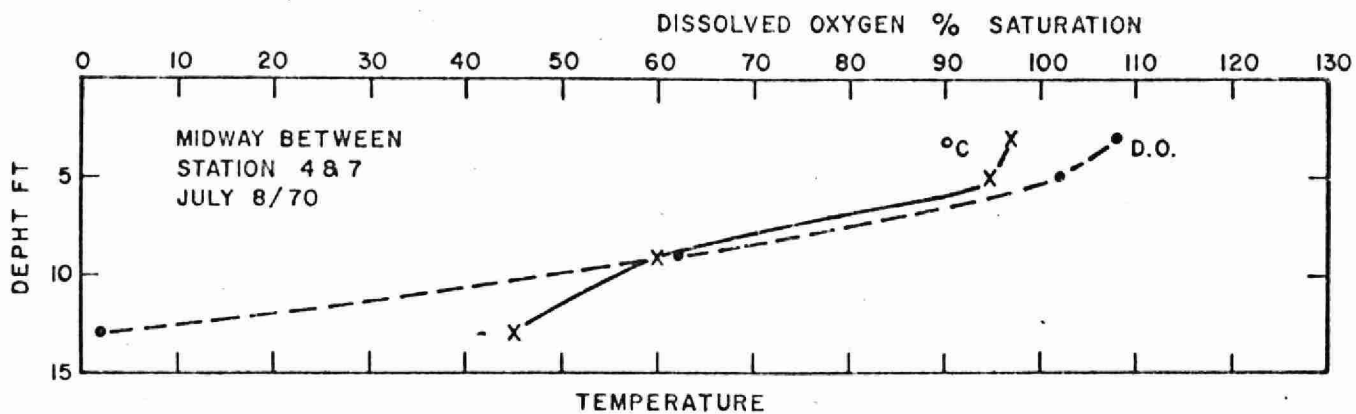
the same order of magnitude as those found during the MID survey. However, a carbon increase occurred from about 5 ppm during the first two days to a range of 12 to 14.5 ppm during the last two days. The reason for this significant increase is now known but it is noted that the second rain during the survey coincided with the increase.

Prepared by: 
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District Engineers Branch

Reference:

BURGER, A., May 1971 - Bacteriological Water Quality of Riley Lake, Ontario Water Resources Commission, Division of Laboratories - internal report

MICHALSKI, M.F.P., & ROBINSON, G.W. - December 1970 - Status of Enrichment of Riley Lake - Township of Ryde, Ontario Water Resources Commission, Division of Laboratories



RILEY LAKE
FIGURE 1

TABLE II

RILEY LAKE

July 5 - 9, 1970
September 24 - 27, 1970

STATION	DISSOLVED OXYGEN % SATURATION	TEMPERATURE ° CENTRIGRADE	pH
6	102	19.9	-
	89	17.2	5.8
5	104	19.9	-
	91	17.4	5.8
4	105	19.9	-
	93	17.5	5.9
7	107	19.6	-
	88	17.4	5.5
8	107	19.7	-
	93	17.4	5.8
3	106	20.0	-
	92	17.5	6.1
2	106	19.9	-
	87	17.5	6.0
9	109	19.6	-
	94	17.4	5.8
1	110	19.8	-
	84	17.4	5.4
10	110	19.8	-
	94	17.4	5.9
11	110	19.9	-
	98	17.4	5.9
24	107	19.8	-
	93	17.4	6.2
23	107	19.9	-
	92	17.2	6.3

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TABLE II (Cont'd)

RILEY LAKE

July 5 - 9, 1970
September 24 - 27, 1970

STATION	DISSOLVED OXYGEN % SATURATION	TEMPERATURE ° CENTRIGRADE	pH
21	111 95	19.8 17.5	- 6.2
22	107 95	20.0 17.6	- 6.4
22D	--- 4	---- 10	- 6.2
19	109 87	20.4 17.2	- 6.0
18	111 89	19.9 17.7	- 6.0
18D	--- 4	---- 10.2	- 6.0
20	113 91	20.1 17.5	- 6.1
17	112 95	20.1 17.5	- 6.2
13	108 95	20.3 17.5	- 6.0
12	108 96	19.9 17.5	- 6.2
14	108 95	20.1 17.6	- 6.1
16	110 97	20.6 17.7	- 6.2
15	107 93	20.2 17.6	- 6.2

TABLE III

RILEY LAKE, 1970

Statistical Bacterial Parametric Summary

PARAMETER	TERM	SURVEY	
		July 5-9, 1970	Sept. 24-27, 1970
TC/100 ml	F	0.90	1.64
	df	23, 96	23, 72
	F (5%)	1.61	1.70
	NSD	NSD	NSD
	ln GM	5.5742	5.1085
	s ²	0.4613	0.1072
	N	120.	96.
	GM	263.5	165.4
	t	6.168	df 214 SD
FC/100 ml	F	0.62	1.43
	df	23, 96	23, 72
	F (5%)	1.61	1.70
	NSD	NSD	NSD
	ln GM	2.1910	1.3007
	s ²	2.8849	1.4802
	N	120.	96.
	GM	8.9	3.7
	t	4.324	df 214 SD
FS/100 ml	F	1.46	0.88
	df	23, 96	23, 72
	F (5%)	1.61	1.70
	NSD	NSD	NSD
	ln GM	0.9031	1.2130
	s ²	0.7433	1.9135
	N	120.	96.
	GM	2.5	3.4
	t	2.014	df 214 SD

NSD = No Significant Difference at 5% Level

SD = Significant Difference at 5% Level

See Appendix B for explanation of statistical terms.

TABLE IV
RILEY LAKE
CHEMICAL RESULTS
July 5 - 9, 1970

SAMPLING POINT	DATE	NITROGEN AS N				PHOSPHORUS AS P		IRON as Fe	ORGANIC CARBON	HARDNESS as CaCO ₃
		FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	TOTAL	SOLUBLE			
19	July 5	.02	.56	.008	<.01	.022	.003	.40	9.5	-
18	July 8	.05	.40	.006	<.01	.027	.004	.34	10	-
20	July 9	.08	1.1	.004	<.01	.016	.003	.30	11.5	-
21	July 6	.10	.54	.012	<.01	.016	.003	.35	9.5	-
22	July 7	.04	.68	.017	<.01	.028	.006	.30	9.5	-
23	July 9	.08	.54	.004	<.01	.018	.004	.30	11.5	-
6	July 6	.08	.52	.012	<.01	.014	.003	.35	9	-
5	July 8	.05	.25	.004	<.01	.011	.002	.30	11.5	-
3A	July 5	.01	.68	.008	<.01	.032	.012	.55	9.5	-
8	July 7	.06	.64	.013	<.01	.014	.004	.35	9	-
2	July 6	.05	.62	.012	<.01	.014	.003	.35	9	-
	July 7	.08	.56	.010	<.01	.016	.003	.35	9	-

Note: All results in ppm except where otherwise indicated

TABLE IV (Cont'd)

RILEY LAKE - July 5 - 9, 1970

SAMPLING POINT	DATE	NITROGEN AS N				PHOSPHORUS AS P		IRON as Fe	ORGANIC CARBON	HARDNESS as CaCO ₃
		FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	TOTAL	SOLUBLE			
9	July 9	.05	.45	.005	<.01	.019	.004	.30	10	-
10	July 8	.09	.45	.006	<.01	.015	.004	.30	9.5	-
11	July 7	.08	.58	.012	<.01	.010	.004	.30	9.5	-
17	July 6	.07	.50	.011	<.01	.016	.003	.35	9.5	-
13	July 5	.02	.64	.008	<.01	.036	.002	.35	9.5	-
12	July 9	.05	.74	.004	<.01	.014	.008	.30	10	-
14	July 8	.03	.40	.005	<.01	.017	.004	.30	9.5	-
15	July 5	.01	.56	.008	<.01	.020	.006	.35	9	-

Note: All results in ppm except where otherwise indicated

TABLE IV
RILEY LAKE
CHEMICAL RESULTS
July 5 - 9, 1970

SAMPLING POINT	DATE	ALKALINITY as CaCO ₃	CALCIUM as Ca	MAGNESIUM as Mg	CHLORIDE as Cl	TURBIDITY in Units	CONDUCTIVITY in Micromhos per cm ³
19	July 5	6	3	1	2	1.5	33
18	July 8	8	5	2	2	3	33
20	July 9	8	4	.5	1	4	31
21	July 6	7	4	.5	2	1.5	32
22	July 7	8	5	1.0	2	1.5	32
23	July 9	8	4	.5	1	4	32
6	July 6	7	4	.5	2	2	32
5	July 8	7	5	2	2	3	32
3A	July 5	7	3	1	1	3	33
8	July 7	9	3	.5	2	1.5	32
2	July 6	9	5	1	1	3	33
	July 7	7	5	.5	2	1.5	32

Note: All results in ppm except where otherwise indicated

TABLE IV (Cont'd)

RILEY LAKE - July 5 - 9, 1970

SAMPLING POINT	DATE	ALKALINITY as CaCO ₃	CALCIUM as Ca	MAGNESIUM as Mg	CHLORIDE as Cl	TURBIDITY in Units	CONDUCTIVITY in Micromhos per cm ³
9	July 9	7	4	.5	1	4	31
10	July 8	7	5	2	1	2	31
11	July 7	8	4	.5	2	2	32
17	July 6	7	4	.5	1	2	32
13	July 5	5	3	1	2	3	32
12	July 9	7	4	.5	2	4	32
14	July 8	8	5	2	1	3	32
15	July 5	7	3	1	2	2	30

Note: All results in ppm except where otherwise indicated

TABLE V

RILEY LAKE

CHEMICAL RESULTS

September 24 - 27, 1970

SAMPLING POINT	DATE	NITROGEN AS N				PHOSPHORUS		IRON as Fe	ORGANIC CARBON	HARDNESS	
		FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	AS P TOTAL	SOLUBLE			As	CaCO ₃
6	Sept. 24	.04	.40	.004	< .01	.008	.002	.40	7		12
	Sept. 25	.07	.52	.004	< .01	.006	.003	.40	4.5		12
	Sept. 26	.03	.46	.004	< .01	.022	.003	.40	14		18
	Sept. 27	.03	.40	.004	< .01	.022	.003	.45	14.5		18
	Med.	.04	.46	.004	< .01	.015	.003	.40	10.5		15
	Max.	.07	.52	.004	< .01	.022	.003	.45	14.5		18
	Min.	.03	.40	.004	< .01	.006	.002	.40	4.5		12
19	Sept. 24	.07	.64	.005	< .01	.018	.004	.45	4		12
	Sept. 25	.03	.44	.006	< .01	.010	.003	.35	5		12
	Sept. 26	.03	.46	.004	< .01	.024	.004	.45	12.5		14
	Sept. 27	.03	.48	.004	< .01	.022	.003	.45	12.5		12
	Med.	.03	.47	.005	< .01	.020	.004	.45	9		12
	Max.	.07	.64	.006	< .01	.024	.004	.45	12.5		14
	Min.	.03	.44	.004	< .01	.010	.003	.35	4		12

Note: All results in ppm except where otherwise indicated

TABLE V (Cont'd)

RILEY LAKE - September 24 - 27/70

SAMPLING POINT	DATE	NITROGEN AS N				PHOSPHORUS AS P		IRON as Fe	ORGANIC CARBON	HARDNESS as CaCO ₃
		FREE AMMONIA	TOTAL KJELDHAL	NITRITE	NITRATE	TOTAL	SOLUBLE			
22	Sept. 24	.07	.50	.004	<.01	.010	.002	.35	4.5	12
	Sept. 25	.09	.56	.005	<.01	.014	.003	.30	5	12
	Sept. 26	.02	.37	.004	<.01	.016	.003	.40	12.5	14
	Sept. 27	.03	.24	.004	<.01	.018	.003	.40	12.5	14
	Med.	.05	.44	.004	<.01	.015	.003	.35	9	13
	Max.	.09	.56	.005	<.01	.018	.003	.40	12.5	14
	Min.	.02	.24	.004	<.01	.010	.002	.30	4.5	12
15	Sept. 24	.03	.36	.006	.01	.008	.002	.35	4.5	12
	Sept. 25	.06	.48	.004	<.01	.008	.003	.30	6.5	12
	Sept. 26	.01	.46	.004	<.01	.026	.003	.35	12.0	12
	Sept. 27	.02	.46	.004	<.01	.042	.003	.40	12.5	14
	Med.	.03	.46	.004	<.01	.017	.003	.35	9.5	12
	Max.	.06	.48	.006	.01	.042	.003	.40	12.5	14
	Min.	.01	.36	.004	<.01	.008	.002	.30	4.5	12

Note: All results in ppm except otherwise noted

TABLE V

RILEY LAKE

CHEMICAL RESULTS

September 24 - 27, 1970

SAMPLING POINT	DATE	ALKALINITY as CaCO ₃	CALCIUM as Ca	MAGNESIUM as Mg	CHLORIDE as Cl	TURBIDITY in Units	CONDUCTIVITY in Micromhos per cm ³
6	Sept. 24	9	4	.5	3	3	34
	Sept. 25	8	4	.5	3	3	33
	Sept. 26	9	5	1.0	2	3	35
	Sept. 27	10	4	2.0	2	3	35
	Med.	9	4	1.0	3	3	34
	Max.	10	5	2.0	3	3	35
	Min.	8	4	.5	2	3	33
19	Sept. 24	8	4	.5	2	2	34
	Sept. 25	7	4	.5	3	3	33
	Sept. 26	7	5	1.0	2	3	33
	Sept. 27	9	4	1.0	2	2	34
	Med.	8	4	.75	2	3	34
	Max.	9	5	1.0	3	3	34
	Min.	7	4	.5	2	2	33

Note: All results in ppm except where otherwise indicated

TABLE V (Cont'd)

RILEY LAKE - September 24 - 27, 1970

SAMPLING POINT	DATE	ALKALINITY as CaCO ₃	CALCIUM as Ca	MAGNESIUM as Mg	CHLORIDE as Cl	TURBIDITY in Units	CONDUCTIVITY in Micromhos per cm ³
22	Sept. 24	9	4	.5	3	2	33
	Sept. 25	9	4	.5	2	3	33
	Sept. 26	8	5	1.0	1	3	33
	Sept. 27	8	5	1.0	2	3	35
	Med.	9	5	.75	2	3	33
	Max.	9	5	1.0	3	3	35
	Min.	8	4	.5	1	2	33
15	Sept. 24	9	4	.5	2	2	33
	Sept. 25	8	4	.5	2	2	33
	Sept. 26	8	3	1.0	1	3	33
	Sept. 27	8	4	1.0	1	3	34
	Med.	8	4	.75	2	3	33
	Max.	9	4	1.0	2	3	34
	Min.	8	3	.5	1	2	33

Note: All results in ppm except where otherwise indicated

APPENDIX A

SIGNIFICANCE OF ANALYSES

BACTERIOLOGICAL INDICATOR ORGANISMS

The TOTAL COLIFORM group is defined, according to Standard Methods (A.P.H.A., 1965), as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hr. at 35°C." This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter-Citrobacter groups are common in soil, but are also recovered in feces in small numbers. Their presence in water may indicate soil run-off or, more important, less recent fecal pollution since organisms of the Enterobacter-Citrobacter groups tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist (Geldreich, 1966).

The FECAL COLIFORM test is an attempt to devise a more specific test for coliforms of intestinal origin. Here, incubation of the organisms is at 44.5°C. Though by no means 100% exclusive for Escherichia coli, this parameter has proved useful as an indicator of recent fecal pollution.

FECAL STREPTOCOCCI (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid, grampositive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the animal body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers. In some waters they may be found alone (Geldreich, 1966). Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

The OWRC Guidelines and Criteria for Water Quality Management in Ontario (1970) state that water used for body contact recreational activities can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds, 1000, 100 and/or 20 per 100 ml respectively, in a series of at least

ten samples per month, including samples collected during weekend periods.

The results of the examinations are reported as organisms per 100 ml of sample.

References: Geldreich, E.C., 1966 - Sanitary Significance of Fecal Coliforms in the Environment. Water Pollution Control Research Series, U.S. Department of Interior Federal Water Pollution Control Administration Publication WP-20-3.

Bennett, E.A., 1969 - Bacteriology of the Great Lakes in "The Great Lakes as an Environment" Edited by D.V. Anderson, Great Lakes Institute Report PR 39, University of Toronto

ALKALINITY

The alkalinity is a measure of the power of a solution to neutralize hydrogen ions (acids) and is expressed in terms of an equivalent amount of calcium carbonate. The alkalinity of natural waters is caused by the following three major materials:

Carbonates

Bicarbonates and other salts of weak acids

Hydroxides (rarely present in Ontario).

The alkalinity of water has little sanitary significance but is of importance in water, sewage and industrial waste treatment practices.

CALCIUM AND MAGNESIUM

Elemental calcium and magnesium do not occur in nature. However, their salts and ions are among the most commonly encountered substances in water. They may result from the leaching of soil and other natural sources or they may be contained in sewage and many types of industrial wastes. The effects of calcium and magnesium are mainly associated with hardness.

CHLORIDES

Chlorides are universally present in domestic and many industrial wastes and naturally in most waters. The OWRC Guidelines and Criteria (1970) state the permissible level for chloride is 250 ppm in water intended for use in public water works. At concentrations above 250 ppm, water begins to taste salty.

COLOUR

Colour is determined by visual comparison of the sample with known concentrations. The intensity is reported in Hazen Colour Units.

The colouration of natural waters may result from organic matter or other chemical substances, which occur naturally or are introduced into the water through waste water discharges.

CONDUCTIVITY

The conductivity of a solution is a measure of its ability to carry an electrical current, and varies with the number and type of ions the solution contains. The presence of dissolved ions such as calcium, chloride, etc., renders water conductive. However, unionized weak acids or bases and uncharged soluble organic materials do not carry a current. In many waters there is a direct linear relationship between dissolved solids concentrations and conductivity. Conductivity serves as a control parameter and is an excellent indicator of water quality changes since it is relatively sensitive to variations in dissolved solids concentrations. Since they are more precise, particularly at low concentrations, conductivity measurements have largely replaced the total dissolved solids test. Conductance is the reciprocal of resistance and is recorded in the unit mho. Natural waters have specific conductance values which are less than one mho and, in order to avoid inconvenient decimals, data are reported in micromhos per centimeter cube.

DISSOLVED OXYGEN

Dissolved oxygen in water is derived from the air directly or through the photosynthetic process of aquatic plants. Ample dissolved oxygen is vital to maintain satisfactory fish and other biological life in water. As a result, a minimum criterion of 5 ppm is recommended. Organic wastes and in some cases inorganic materials exert, upon decomposition, an oxygen demand which may deplete the dissolved oxygen below levels required by aquatic life.

The content of dissolved oxygen in water at equilibrium with a normal atmosphere is a function of the temperature and salinity of the water, the ability of water to hold oxygen decreasing with increases in temperature or dissolved solids. Natural waters are seldom at equilibrium and seldom exactly saturated with dissolved oxygen, for temperatures are changing and physical chemical, bio-chemical, or biological activities are utilizing or liberating oxygen.

HARDNESS

This term is applied to the soap-neutralizing power of water. Hardness is attributable principally to calcium and magnesium cations and is independent of the

anions in solution. The hardness generally reflects the nature of the geological formations with which it has been in contact; however, some industrial wastes and return flow from irrigation drainage will affect hardness.

No specific limit is placed on hardness although it is usually recommended that water for domestic uses should contain less than 250 ppm hardness as CaCO_3 . This objective has been used to avoid excessive soap consumption.

IRON

Iron appears in water as metallic ions, in organic compounds, and as a colloid.

The metallic ion form is due to corrosion of metallic iron and its alloys, the discharge of iron-bearing industrial wastes, and the leaching of soluble iron salts from soil and rocks. As an ion, it may be present in the ferrous or bi-valent form such as ferrous bicarbonate which can only exist in the absence of oxygen, or the ferric or tri-valent form such as ferric hydroxide (a precipitate) which is almost completely insoluble. Water can dissolve greater amounts of iron as ferrous bicarbonate when it is nearly free of dissolved oxygen, contains adequate amounts of carbon dioxide, does not have a pH above 7.5, and organic substances arising from decomposition are present which can reduce ferric hydroxide.

Also, humic acids present in so-called brown waters, form colloiddally dissolved humates with iron. These organic-iron sols are much more stable than inorganic bicarbonate solutions and for this reason, humus waters usually contain considerable amounts of iron even in the presence of dissolved oxygen.

Therefore, the conditions in most surface waters (eg. high oxygen content) are opposite to those that favour the solution of iron. However, in an eutrophic lake where the oxygen content on the bottom water sinks to nearly zero, then all the conditions for the reduction of ferric hydroxide and the solution of ferrous bicarbonate are realized, since decomposing organic substances and aggressive carbon dioxide are present. Iron is reduced in the mineral fraction of suspended particles and in the bottom sediments, and dissolved as ferrous bicarbonate. Throughout the stagnation, the iron content of the bottom

waters constantly increases. Upon recirculation and the introduction of oxygen into the oxygen-deficient waters, the iron re-precipitates and settles on the bottom, thereby being trapped in the bottom waters. As a result, there is a progressive iron enrichment in the sediment of eutrophic lakes.

The permissible criterion for iron in water supplies is 0.3 ppm.

NITROGEN

Free ammonia nitrogen is the soluble product in the decomposition of nitrogenous organic matter. It is also formed when nitrites and nitrates are reduced to ammonia either biologically or chemically. Small amounts of ammonia, too, may be taken out of the atmosphere by rain water. The following values may be of general significance in appraising free ammonia content: Low: 0.015 - 0.03 ppm, Moderate: 0.03 - 0.10 ppm, High: 0.10 ppm or greater.

Total kjeldahl is a measure of the total nitrogenous matter present except that measured as nitrite and nitrate. The total kjeldahl less the ammonia nitrogen gives a measure of the organic nitrogen present. Ammonia and organic nitrogen determinations are important in assessing the availability of nitrogen for biochemical utilization. The normal range for total kjeldahl is 0.1 - 0.5 ppm.

Nitrite nitrogen is usually an intermediate oxidation product of ammonia. The significance of nitrites, therefore, varies with their amount, source and relation to other constituents of the samples, notably the relative magnitude of ammonia and nitrate present. Since nitrite is rapidly and easily converted to nitrate, its presence in concentrations greater than a few thousandths of a part per million is generally indicative of active biological processes in the water.

Nitrate nitrogen is the end product of aerobic decomposition of nitrogenous matter, and its presence carries this significance. Nitrate concentration is of particular interest in relation to the other forms of nitrogen that may be present in the sample. Nitrates occur in the crust of the earth and are a source of its fertility. The following ranges in concentration may be

used as a guide: Low - less than 0.1 ppm; Moderate - 0.1 - 1.0 ppm; High - greater than 1.0 ppm.

pH

The symbol pH is used to designate the logarithm (base 10) of the reciprocal of the free hydrogen-ion concentration. It is used to express the intensity of the acid or alkaline condition of a solution. The practical pH extends from 0, very acid, to 14, very alkaline, with the middle value of pH 7 corresponding to exact neutrality (at 25°C).

pH does not measure the total amount of acidity (or alkalinity) in the water, since some may be in a combined form and therefore will not be included in the pH measurement of free hydrogen ions. The combined forms can still be released to react with bases. The commonest example in water is the bicarbonate ion, which can react with acids to form carbonic acid, or with bases to form carbonates and water.

The OWRC permissible criterion for pH in public surface water supplies is a range from 6.0 to 8.5.

PHOSPHORUS

Phosphorus is an essential plant nutrient and is believed to play an important role in the deterioration of the quality of natural waterways by promoting an overabundance of plants. It occurs in natural and waste waters in several different chemical combinations, such as orthophosphate (PO_4), organic phosphates and polyphosphates. Since most or all of these forms can eventually be used by plants and animals, determination of the TOTAL PHOSPHORUS concentration is more relevant than measurement of individual phosphorus compounds.

The SOLUBLE PHOSPHORUS content of a sample is that fraction which will pass through a filter and will react chemically with the reagents used to determine the concentration of orthophosphate yielding a positive test response. It is generally accepted that some organic and even particulate forms can react similarly to orthophosphate and, for this reason, the results are often referred to as "soluble reactive phosphorus", which removes the implication that the test measures only orthophosphate.

TURBIDITY

Turbidity is due to the material in suspension which may not be of sufficient size to be seen as individual particles by the naked eye, but which reduces the passage of light through the liquid. High turbidity is undesirable in natural waters, particularly those which are used for recreational purposes. It is an expression of the optical property of a sample and results are reported in Turbidity Units.

Reference: Outlines of Analytical Methods compiled by
Dr. T.G. Brydges, Chemistry Branch, Division
of Laboratories, OWRC.

APPENDIX B -- Explanation of Statistical Terms in
Table III

- F the calculated analysis of variance statistic or the F ratio.
- df degrees of freedom of the F ratio for "between group" variation and "within group" variation.
- F(5%) the critical F ratio from a statistics table.
- If the calculated F is greater than the F(5%), a significant difference (SD) occurs between the groups in the analysis. If F is less than F(5%), no significant difference (NSD) occurs.
- ln GM the natural logarithm of geometric mean for all groups in the analysis of variance when NSD occurs.
- s^2 the variance in natural logarithm.
- N the number of values in the analysis.
- GM the geometric mean of the bacterial level.
- t the calculated test of significance or t-test to determine the between survey difference.
- If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.



RYDE TOWNSHIP

RILEY LAKE
P.O.

PUBLIC
WHARF

RILEY
CREEK

RILEY LAKE

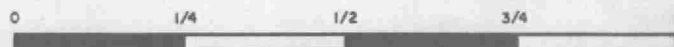
RYDE TOWNSHIP

BALL'S
BAY

HANNA'S
BAY

TO BLACK
RIVER

STATUTE MILES



LEGEND

10 ● SAMPLING POINT

→ FLOW DIRECTION

OVERALL BACTERIAL GEOMETRIC MEAN DENSITY PER 100ML.			
SURVEY DATES	TOTAL COLIFORM	FECAL COLIFORM	FECAL STREP
JULY 5-9	263.5	8.9	2.5
SEPT 24-27	165.4	3.7	3.4

ONTARIO WATER RESOURCES COMMISSION

1970 RECREATIONAL LAKES PROGRAM

RILEY LAKE

SCALE: AS SHOWN

DRAWN BY: A.J.H.

DATE: JULY 1971

CHECKED BY: R.C.M.

DRAWING NO: 71-63-DE